Lecture 13

Climate Modeling

Ch. 2 (p. 31-39)

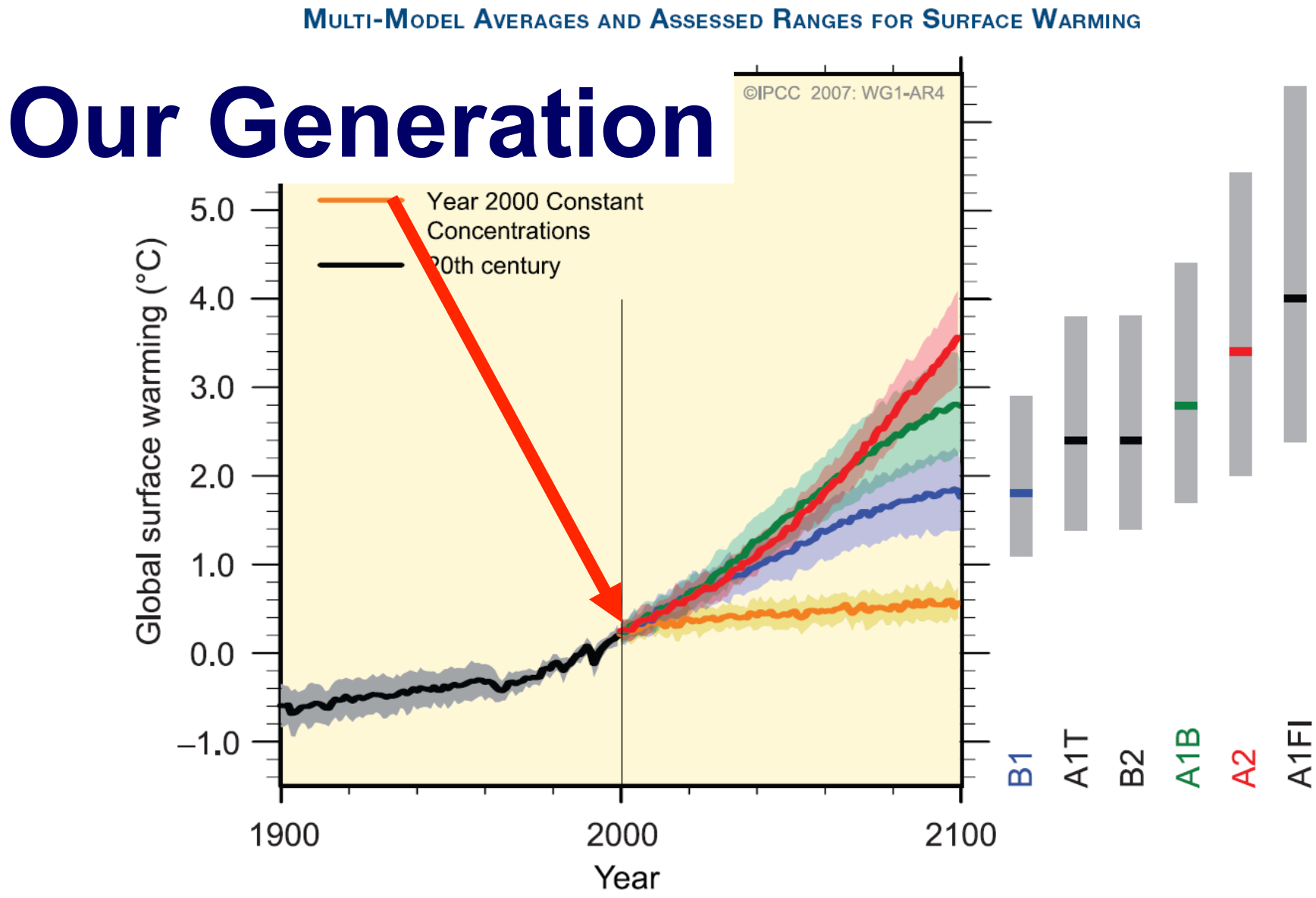
- **Why use models?**
- **What models are available?**
- **How to evaluate models?**
- **Why simple models?**

Natural or Anthropogenic?

IPCC AR4; IPCC TAR

Detection and Attribution

Predict the Future



Our Generation

:

What types of climate models are used to study climate change?

Zero-Dimensional

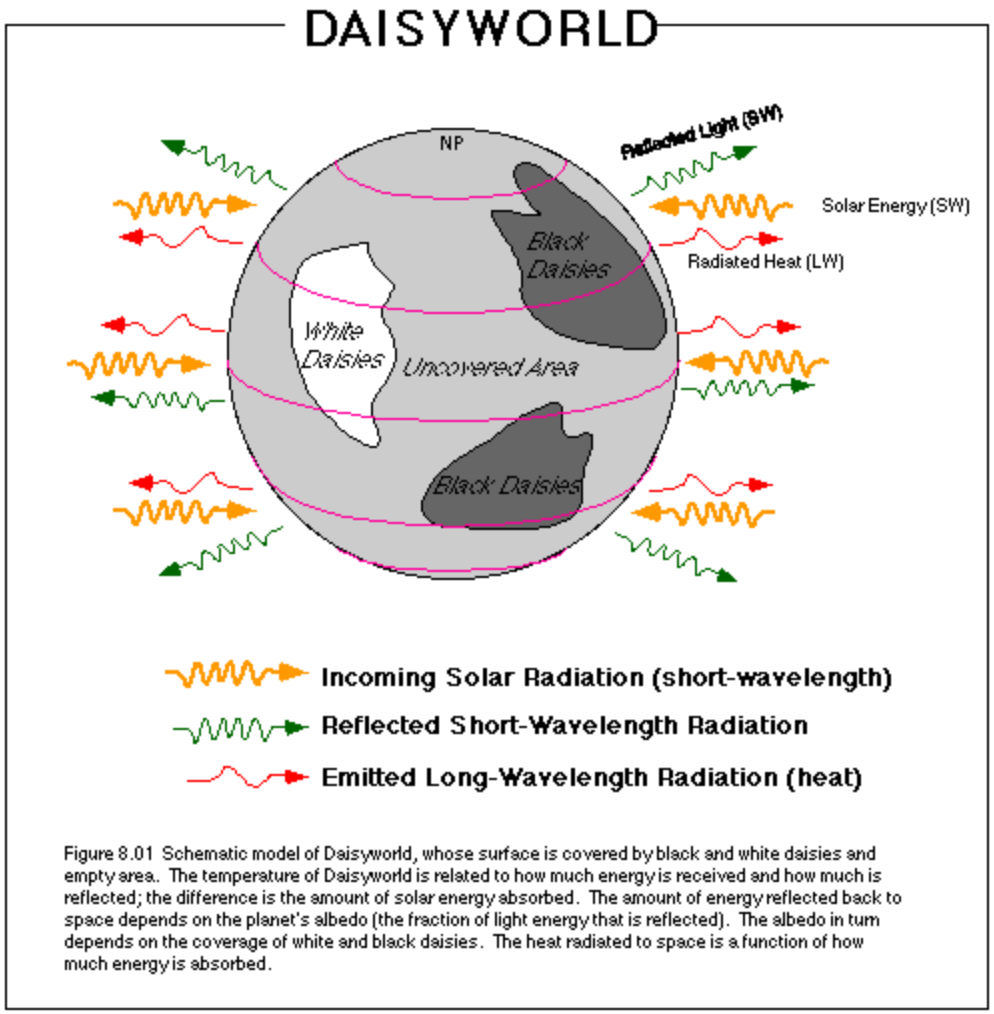
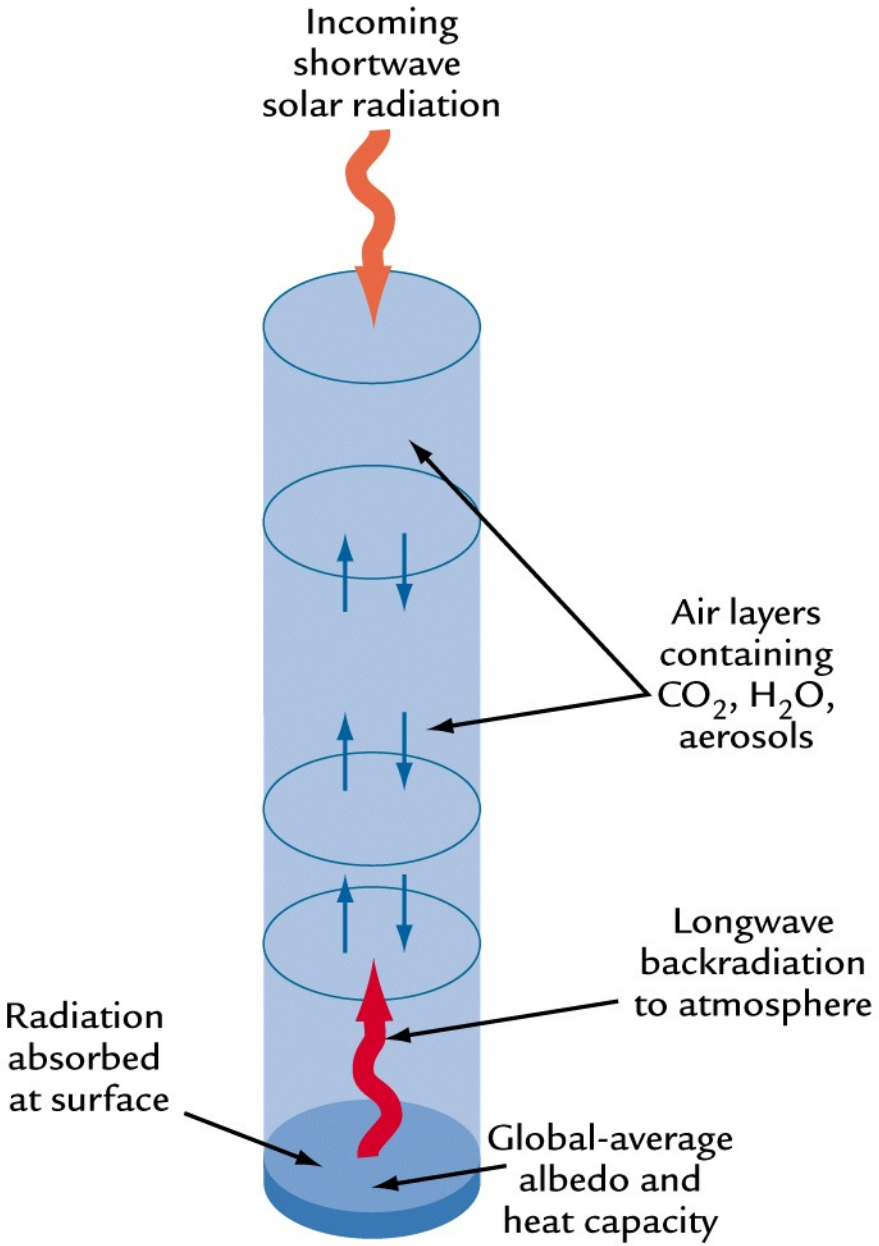


Figure 8.01 Schematic model of Daisyworld, whose surface is covered by black and white daisies and empty area. The temperature of Daisyworld is related to how much energy is received and how much is reflected; the difference is the amount of solar energy absorbed. The amount of energy reflected back to space depends on the planet's albedo (the fraction of light energy that is reflected). The albedo in turn depends on the coverage of white and black daisies. The heat radiated to space is a function of how much energy is absorbed.

No explicit east-west, north-south, up-down, and time dimensions.

1-Dimensional



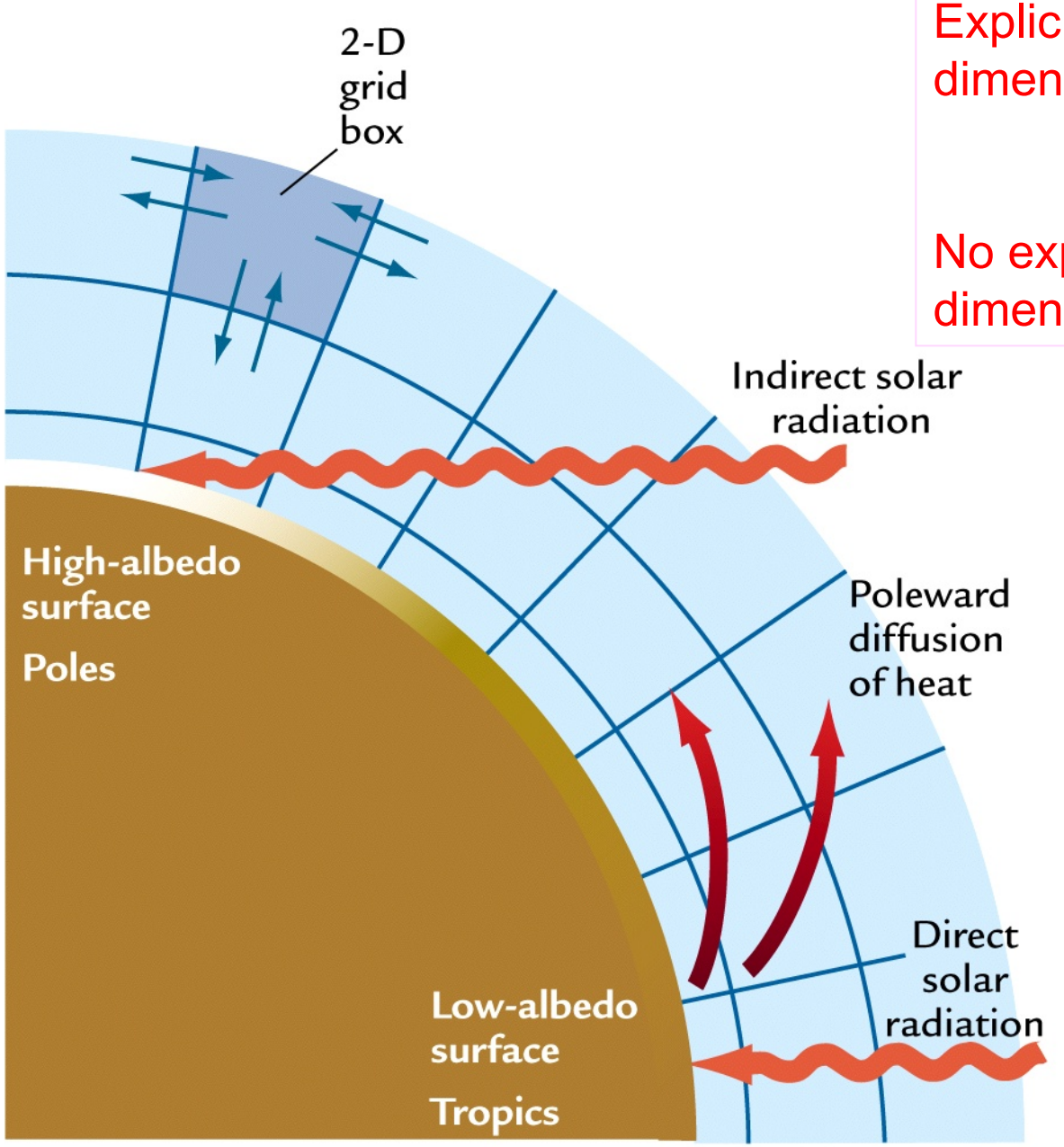
Explicit up-down dimension!

No explicit east-west, north-south, and time dimensions.

2-Dimensional

Explicit north-south and up-down dimensions!

No explicit east-west and time dimensions.



3-Dimensional Global Climate Models

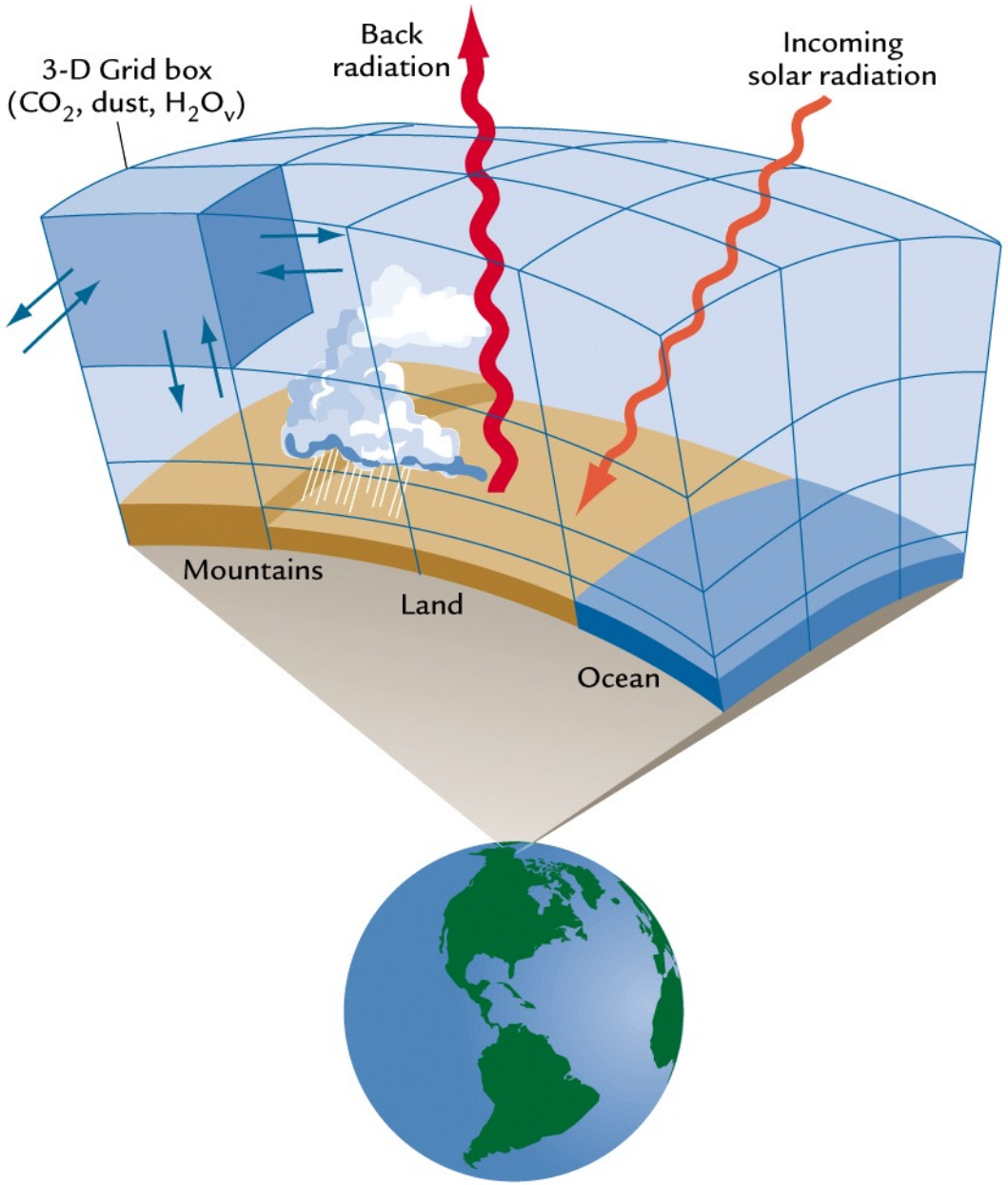
Explicit east-west, north-south, up-down, and time dimensions!

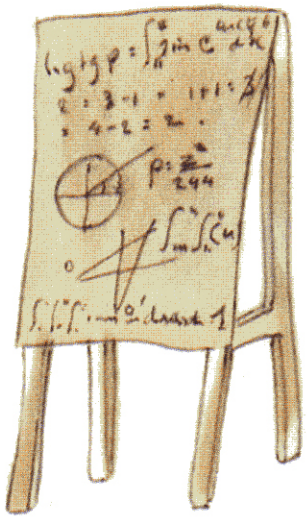
Each grid box can be:

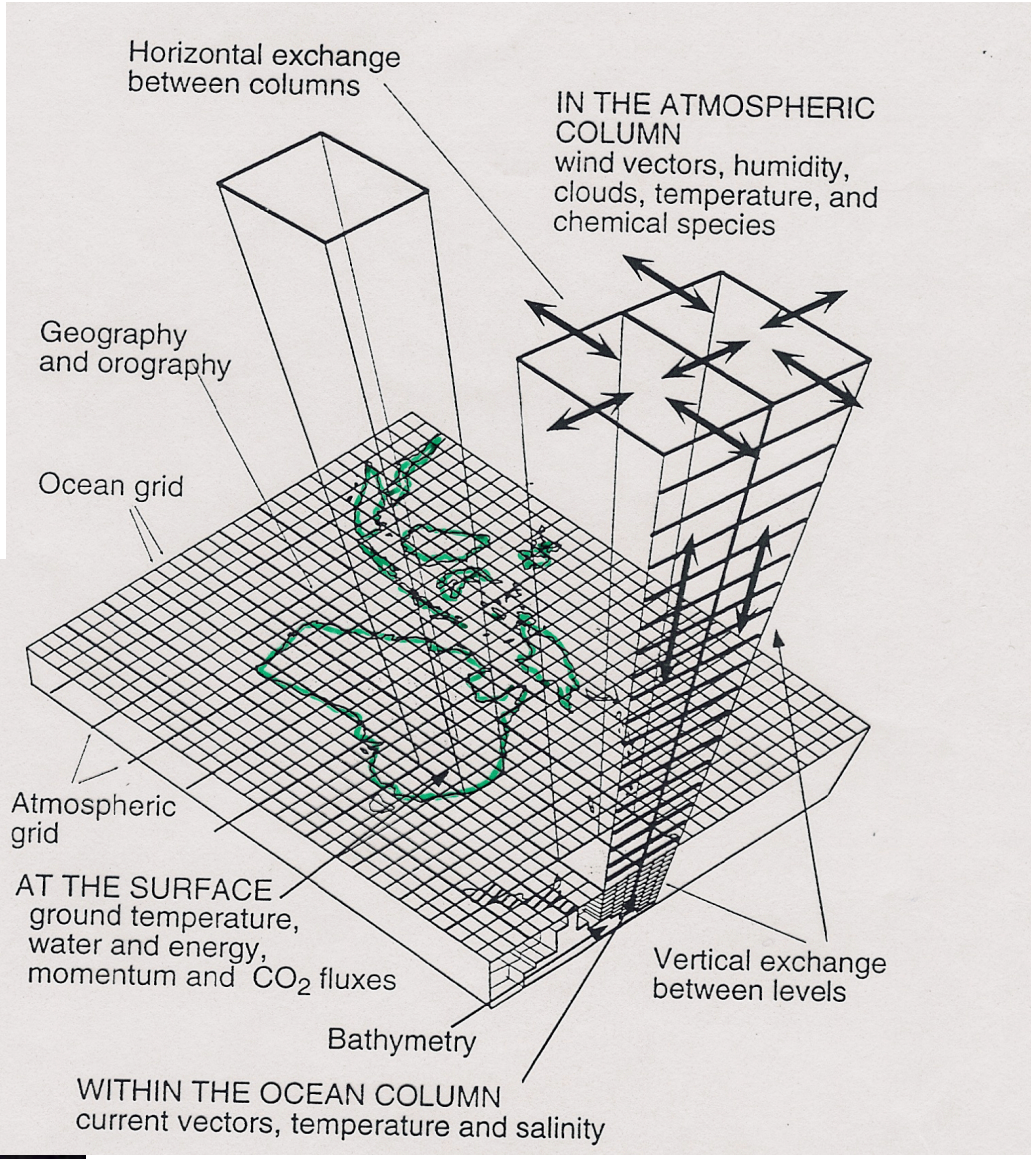
One of the climate system components,

State variables,

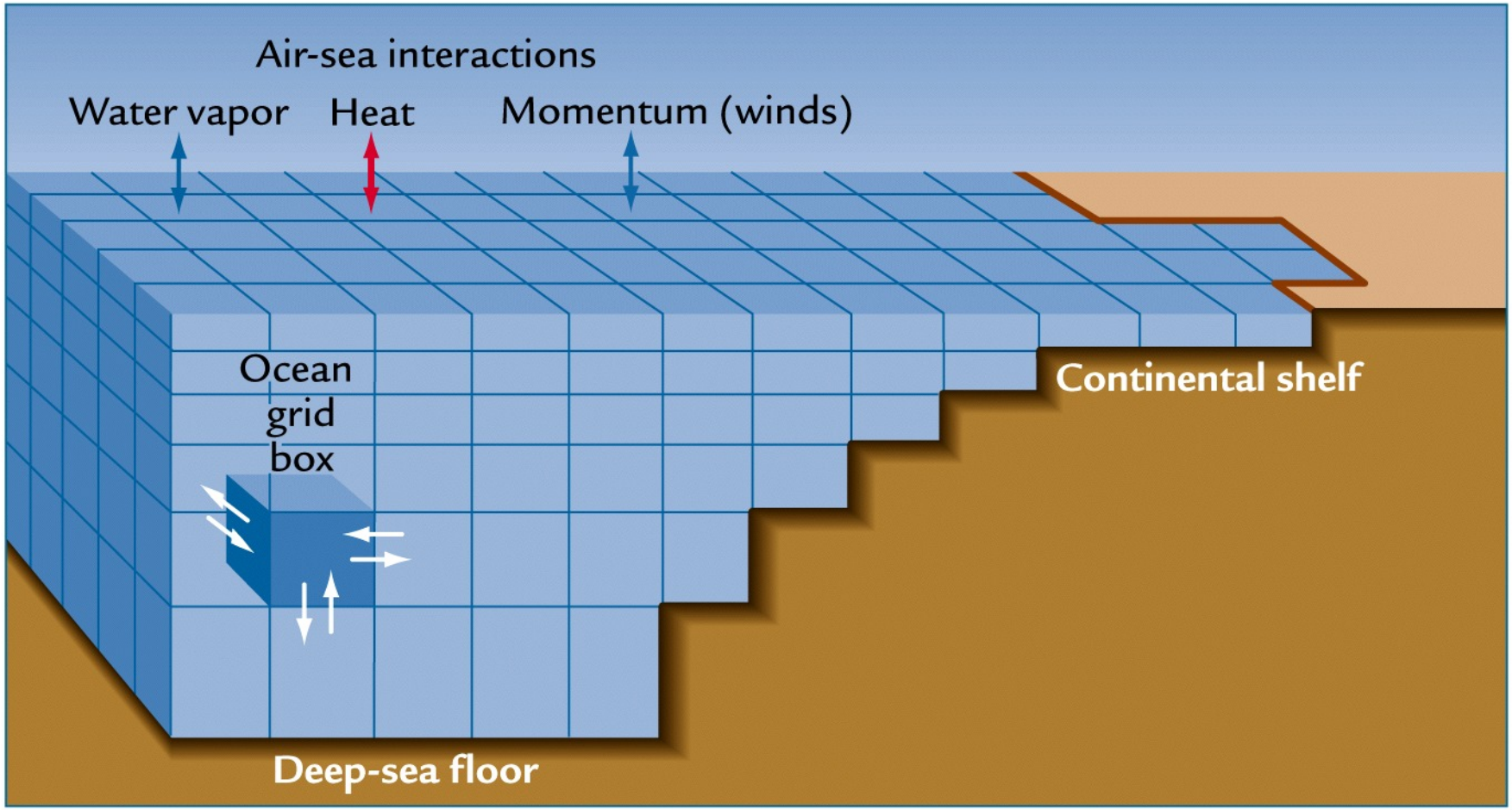
Processes.





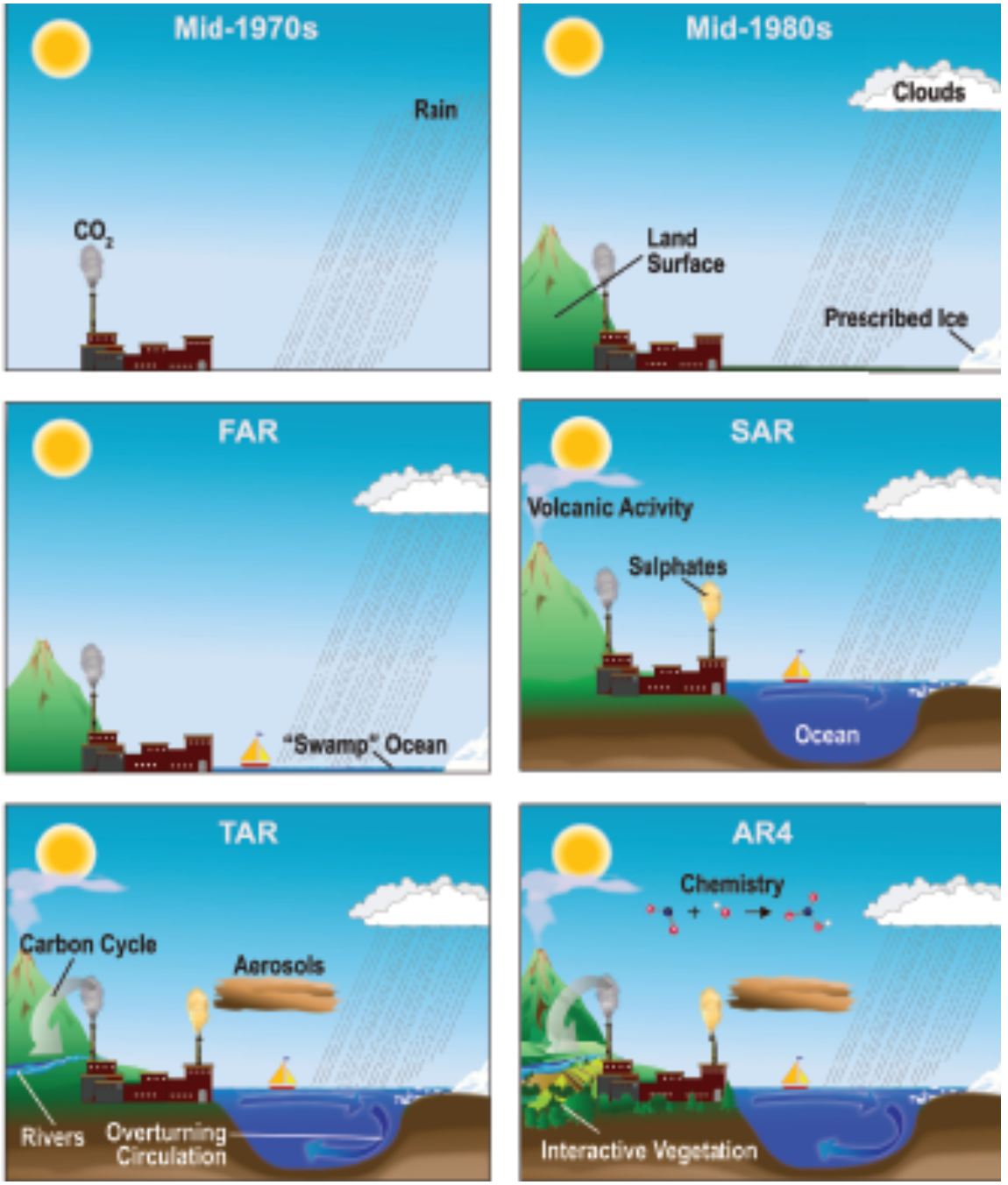

Horizontal exchange between columns
IN THE ATMOSPHERIC COLUMN
wind vectors, humidity, clouds, temperature, and chemical species
Geography and orography
Ocean grid
Atmospheric grid
AT THE SURFACE
ground temperature, water and energy, momentum and CO_2 fluxes
Vertical exchange between levels
Bathymetry
WITHIN THE OCEAN COLUMN
current vectors, temperature and salinity

Ocean GCMs



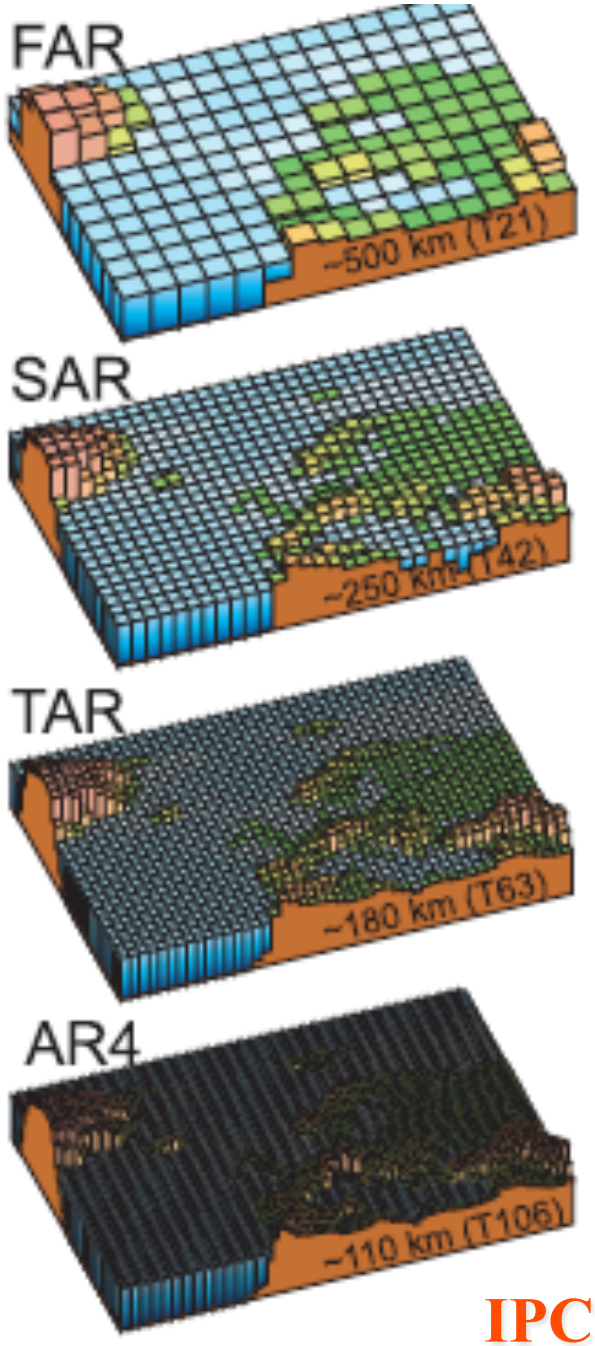
Computes: currents, temperature, salinity, and air-sea interactions

Evolution of Climate Models Over the Last Few Decades: Increased Complexity



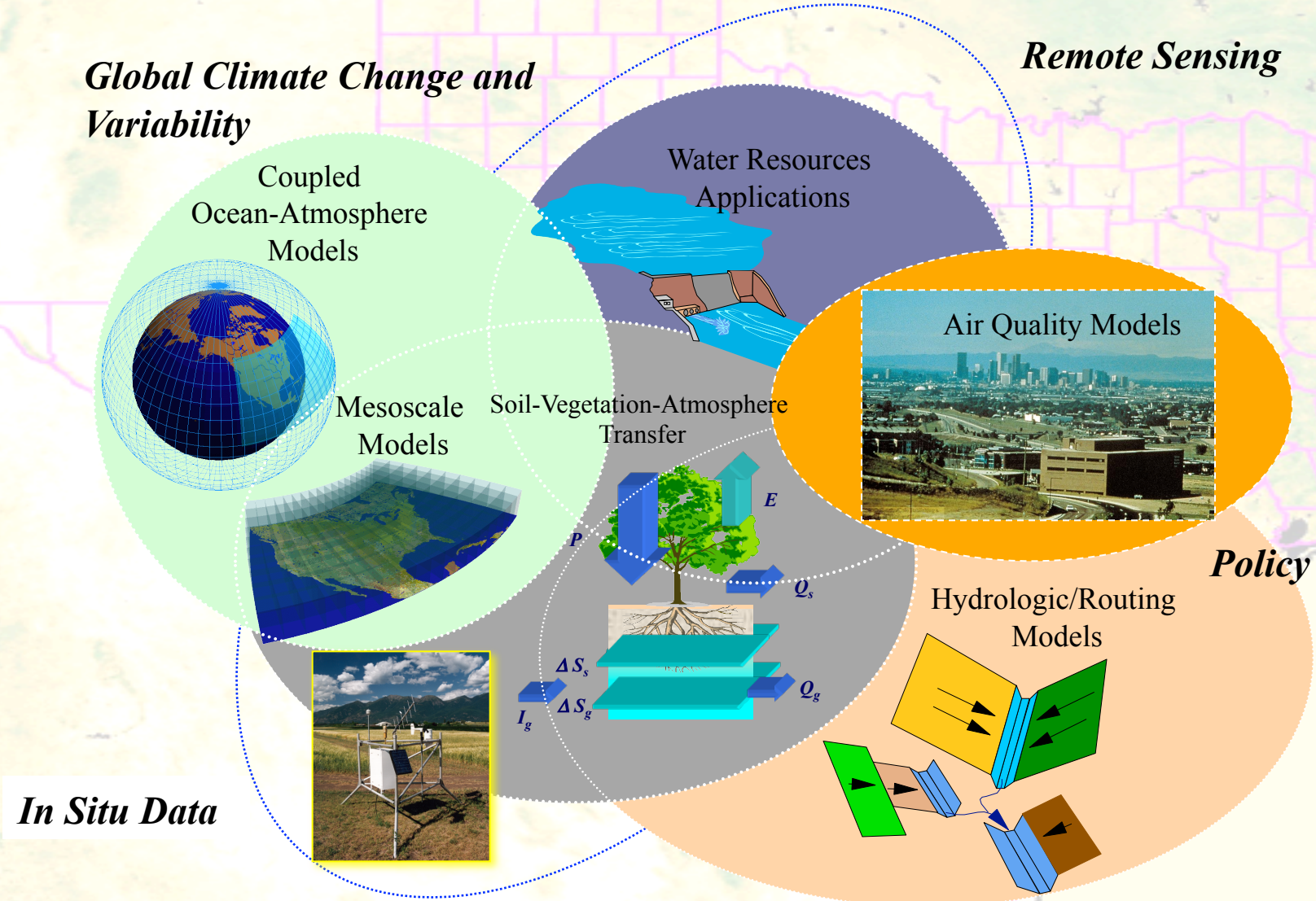
IPCC 2007

Evolution of Climate Models Over the Last Few Decades: Increased Spatial Resolution



IPCC 2007

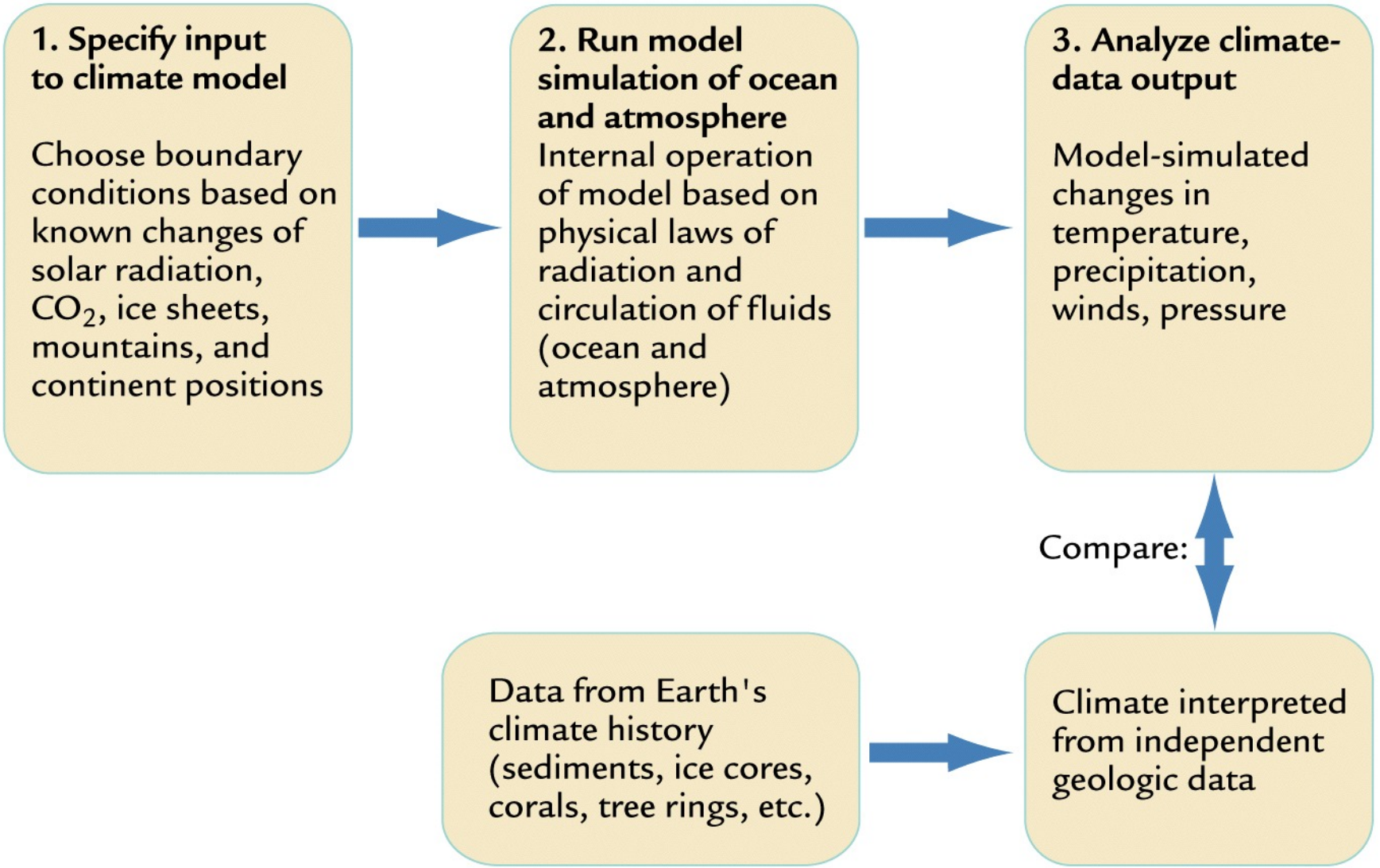
An Integrated Framework for Modeling and Assessment




World's Fastest Supercomputer
35.6 trillion math operations per second
640 nodes, 5104 processors
Occupies 4 tennis court
Earth Simulator Project
4/19/2002

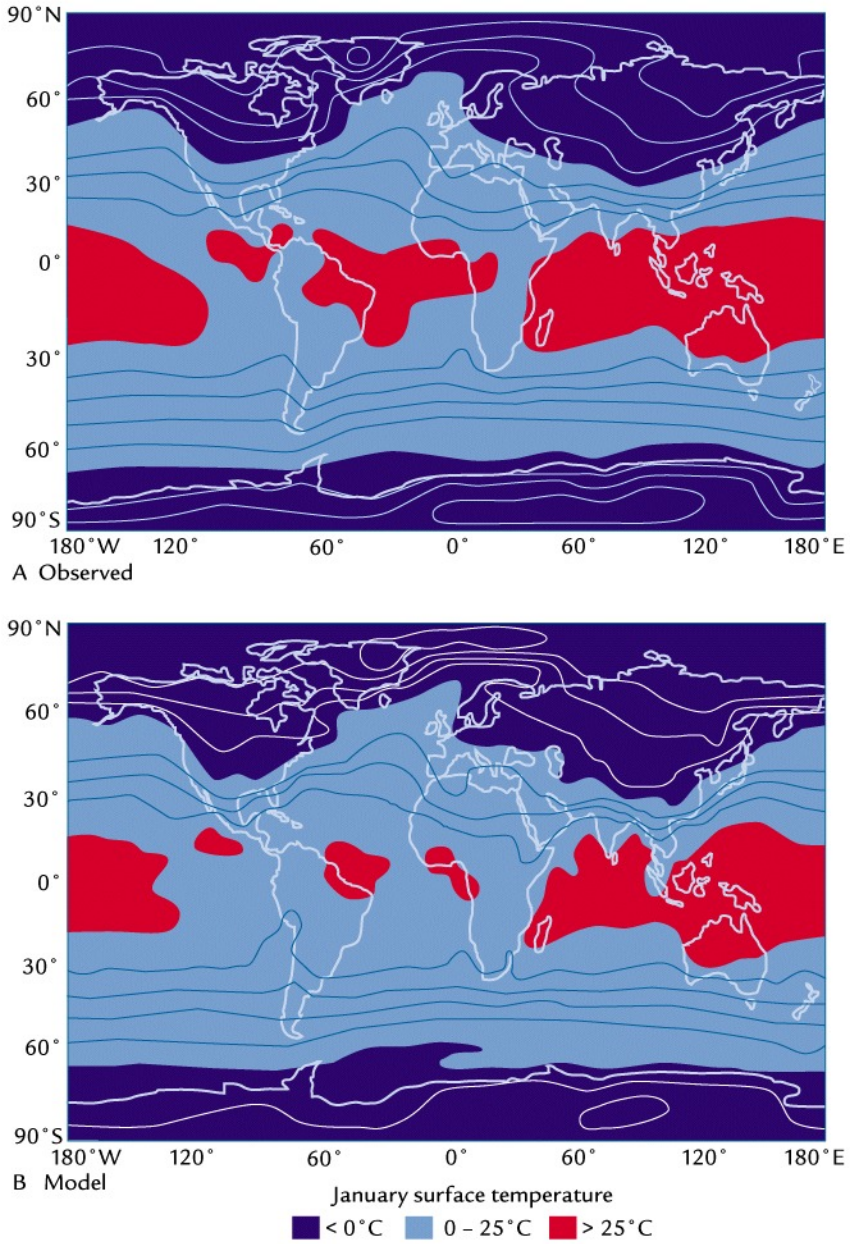
Texas Advanced Computer Center

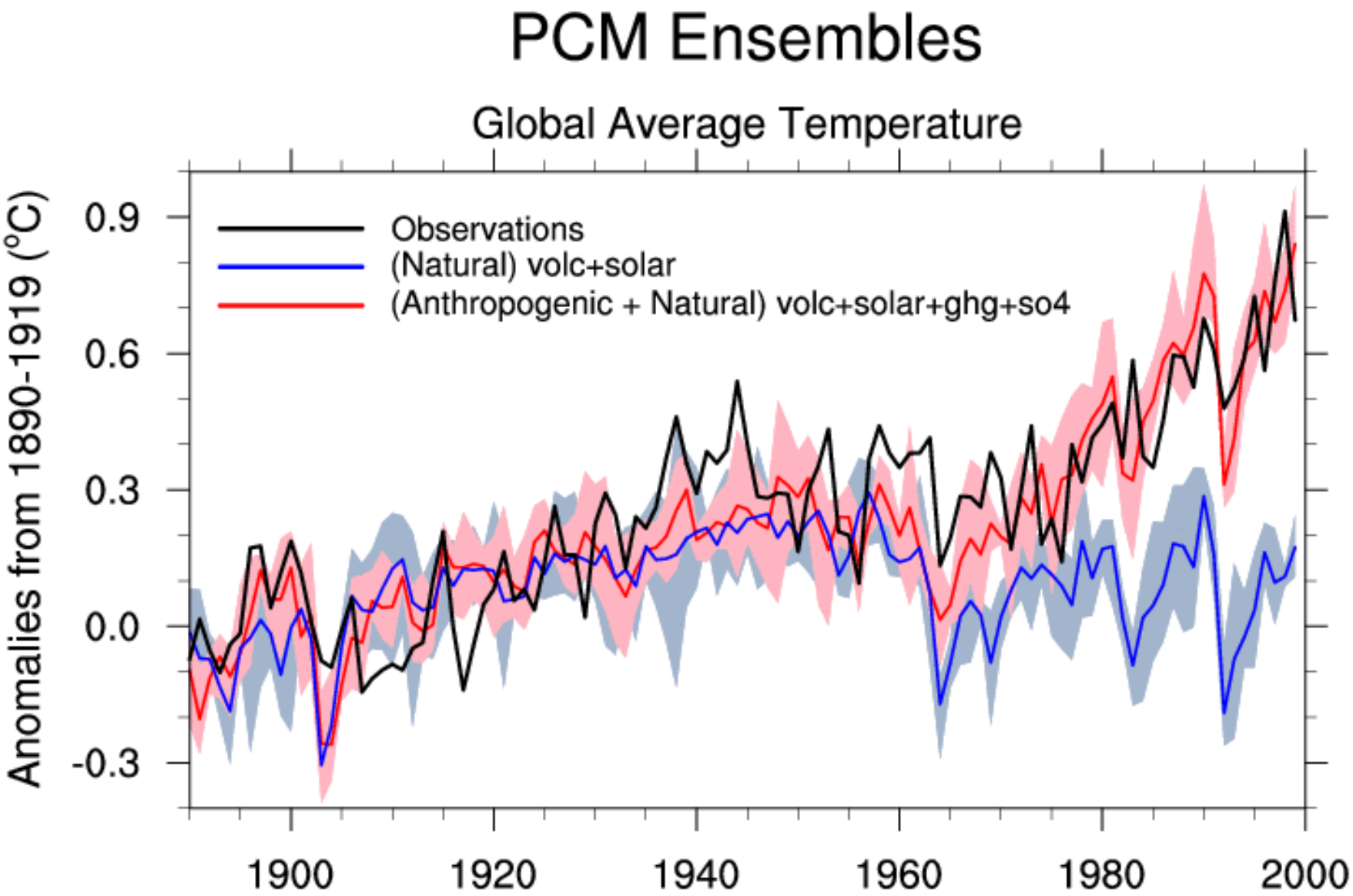
How to Evaluate Climate Models?



Present-day (Control Case) Simulations

See NCAR CCSM Website for more results




PCM Ensembles
Global Average Temperature
Anomalies from 1890-1919 (°C)
0.9
0.6
0.3
0.0
-0.3
Observations
(Natural) volc+solar
(Anthropogenic + Natural) volc+solar+ghg+so4
1900
1920
1940
1960
1980
2000

Examples of Climate Change Experiments

See IPCC Report for details

Greenhouse gases

Sulfate aerosols
(direct and indirect)

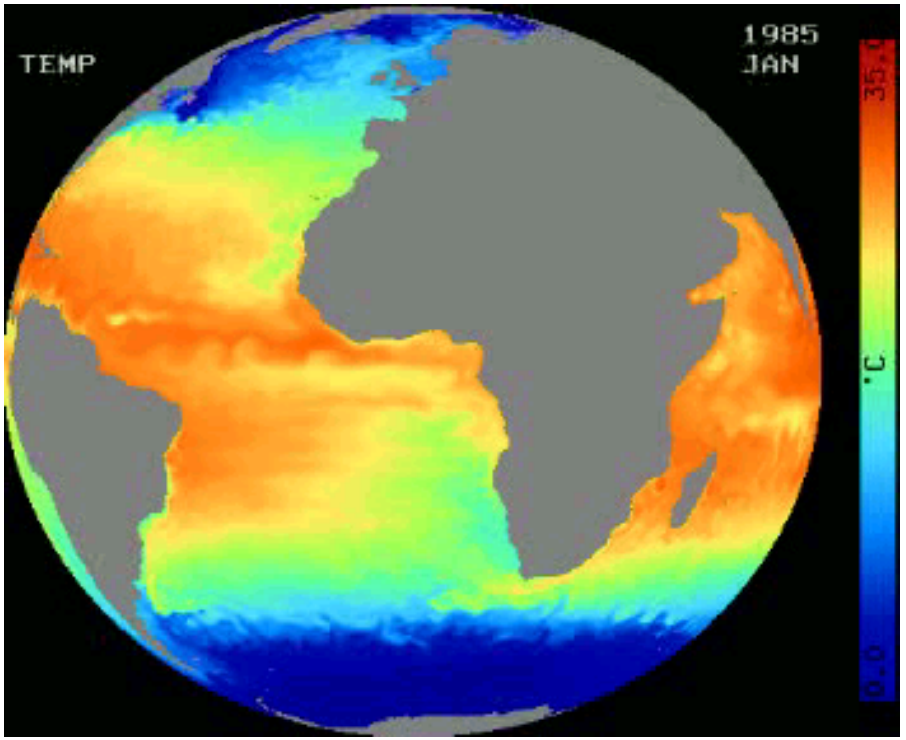
Stratospheric ozone

Biomass burning

Volcanic eruptions

Solar irradiance change

Various energy/emissions
use strategies



The Future of Climate Modeling

Higher resolution, greater regional fidelity

Increased sophistication: e.g., ecosystem dynamics and biogeochemical cycles

Future projections need more sophisticated socio-economic scenarios

Assessment science:

vulnerability,

mitigation,

adaptation,

equity,

regulatory environments, etc.

Confluence of the natural and the social science